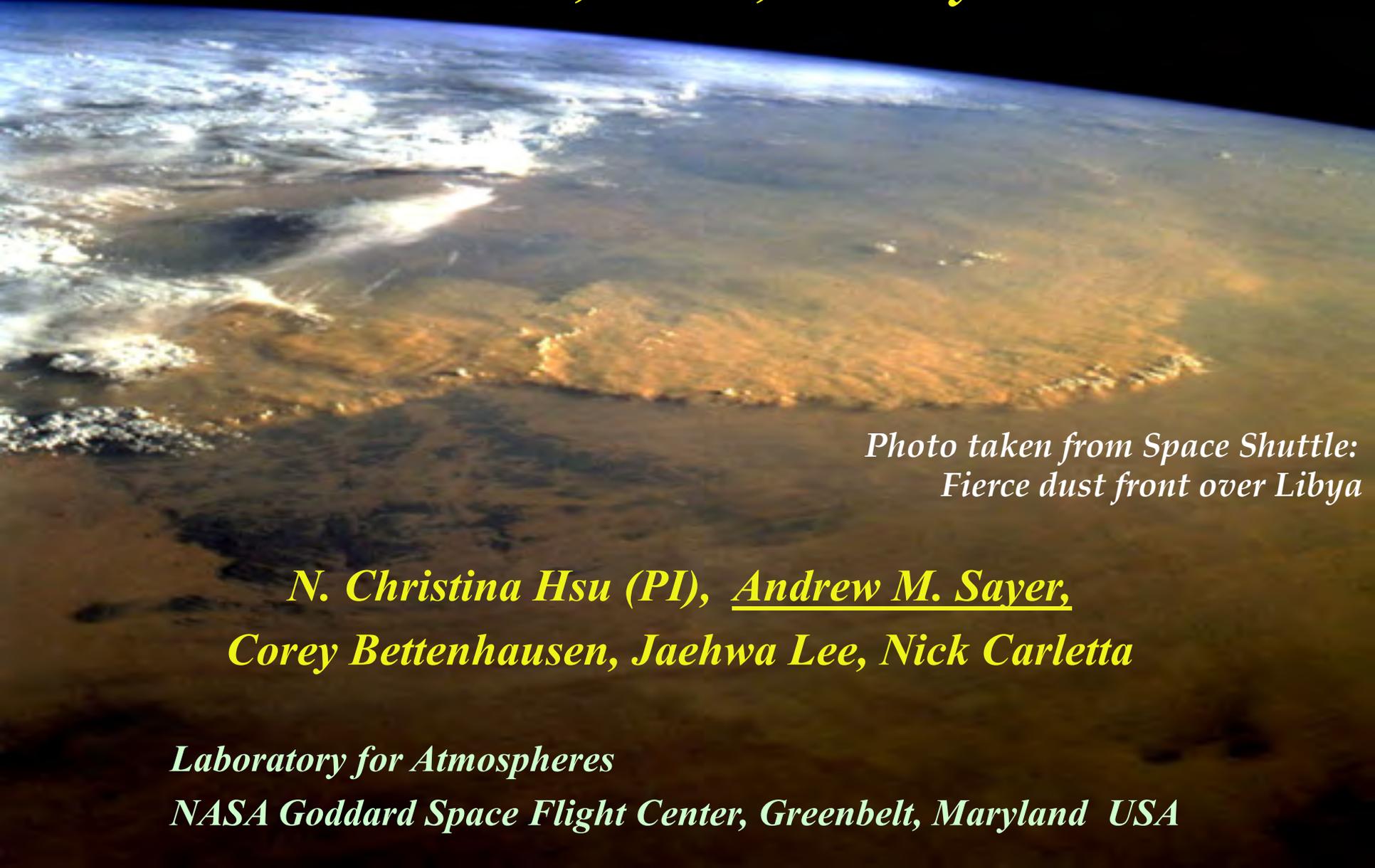


Recent Updates to e-Deep Blue Aerosol Products: MODIS C6, VIIRS, and Beyond



*Photo taken from Space Shuttle:
Fierce dust front over Libya*

*N. Christina Hsu (PI), Andrew M. Sayer,
Corey Bettenhausen, Jaehwa Lee, Nick Carletta*

Laboratory for Atmospheres

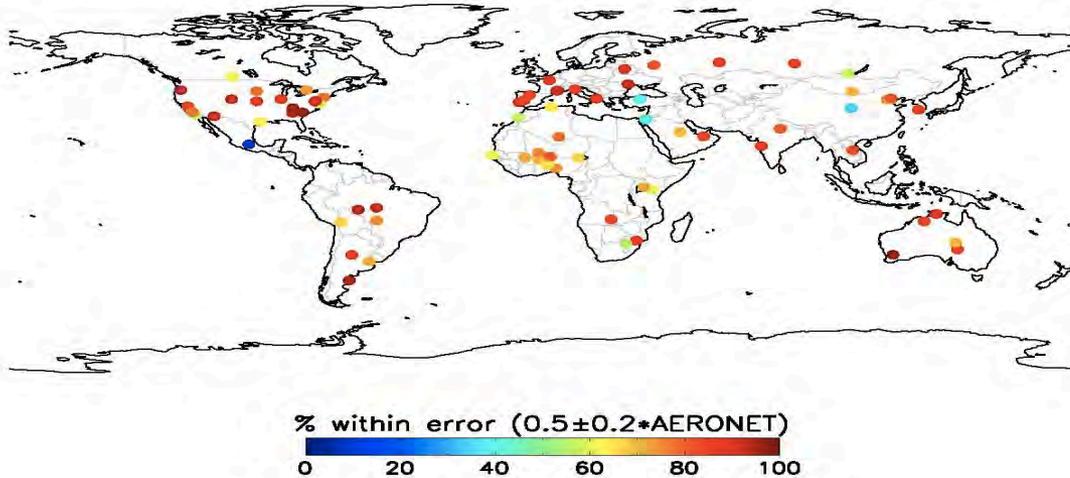
NASA Goddard Space Flight Center, Greenbelt, Maryland USA



Recent major upgrades to the e-Deep Blue aerosol products

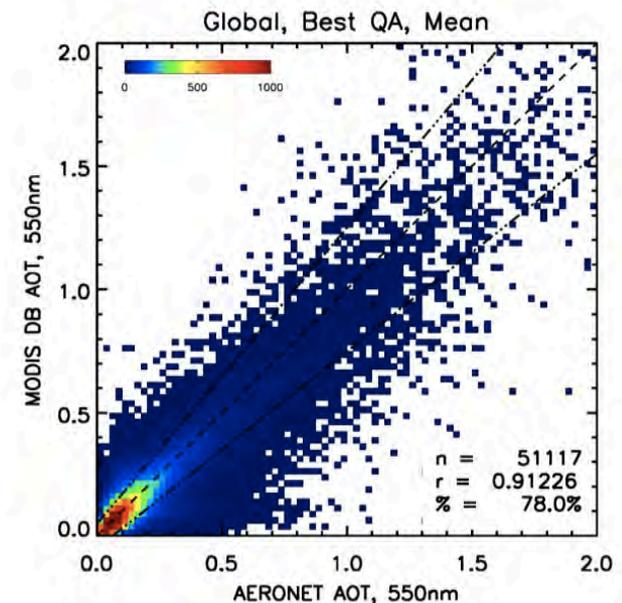
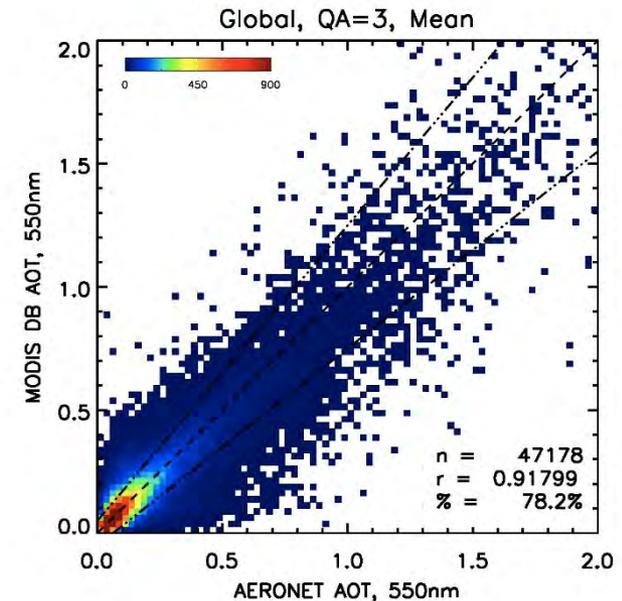
- **Expand coverage from *arid and semi-arid* regions into *vegetated* (SeaWiFS, MODIS C6, and VIIRS) areas as well as *oceans* (SeaWiFS and VIIRS only)**
- **Move away from the *static* surface reflectance database**
 - **implemented *dynamic* surface reflectance determination;**
 - **include *changes in vegetation* using NDVI.**
- **Improve cloud screening scheme, particularly for the presence of *thin cirrus* under *moist deprived* regions**
- **Better identify *strongly absorbing mineral dust* by using both *visible and IR channels* simultaneously**

MODIS C6 Deep Blue Global AOT Validation



- Over land, the expected error is $\pm(0.05+0.20 * \text{AOT})$
- Globally, 78.2% of QA=3 data and 78.0% of QA=2,3 data match within the expected error

Reference: Sayer et al, Validation and uncertainty estimates for MODIS Collection 6 "Deep Blue" aerosol data, JGR, 2013.



Applying Polarization Correction to Terra L1B data for *Deep Blue* Aerosol Retrieval (PC algorithm developed by ocean color team)

$$I_m/M_{11} = I_t + m_{12} (Q_t \cos 2\alpha + U_t \sin 2\alpha) + m_{13} (-Q_t \sin 2\alpha + U_t \cos 2\alpha)$$

I_m : TOA MODIS measured radiance

I_t : TOA MODIS expected radiance

Q_t , U_t : linear Stokes vector components,
modeled from Rayleigh and glint

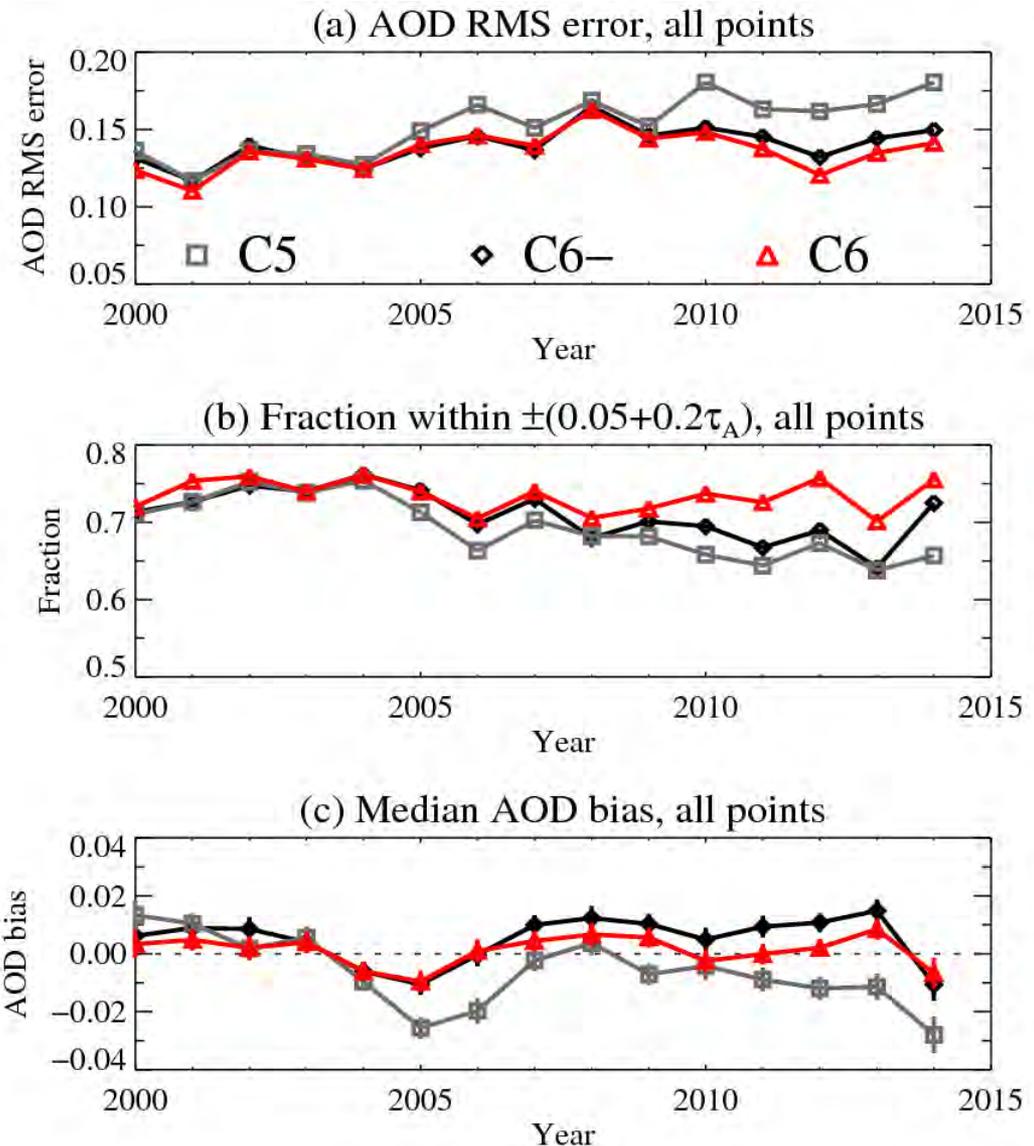
α : angle between incident light and sensor
reference plane

M_{11} , m_{12} , m_{13} : instrument characterization parameters

(Meister et al., 2005, Appl. Opt.)

- Investigated effects of calibration updates on Deep Blue Terra validation
- In-house reprocessing of L2 data using different L1b data versions
 - MCST data (**C6-**) result in significant improvement in later years compared to **C5** L1bs
 - Additional RVS & polarisation corrections from OBPG (**C6**) further decrease errors
 - Ongoing **radiometric calibration** work is **vital** to ensure a **time series of consistent high quality**

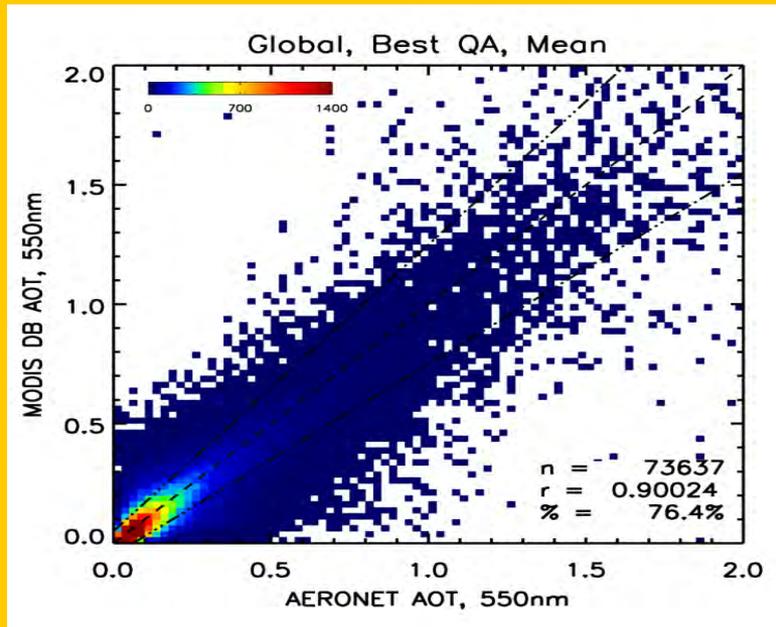
**SEE ALSO
BETTENHAUSEN ET AL.
POSTER**



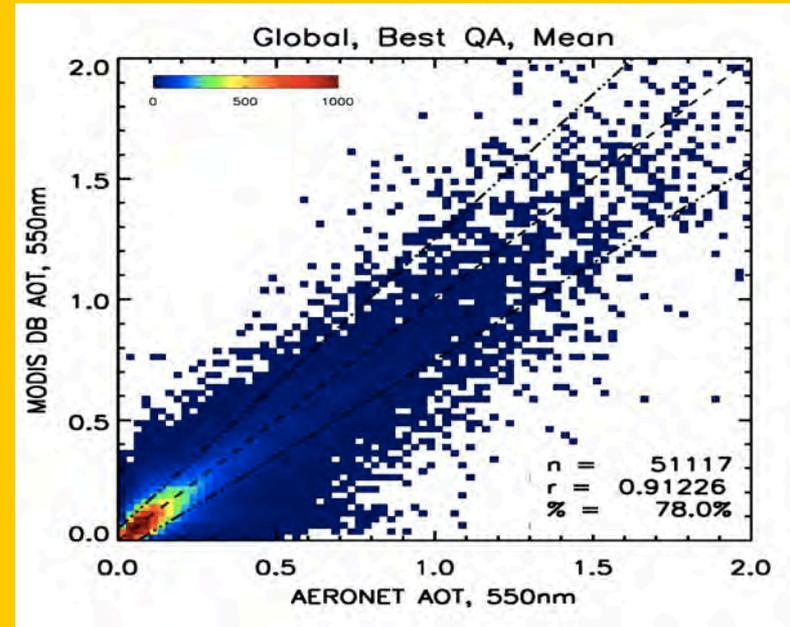
MODIS C6 Deep Blue Aerosol Retrieval Validation

Global Statistics of the Comparisons of MODIS with AERONET AOT: Terra vs. Aqua

Terra



Aqua



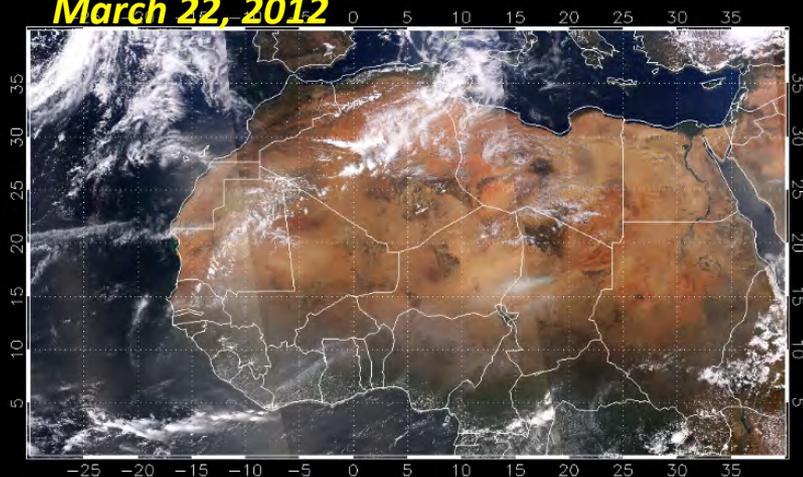
- Over land, the expected error is $\pm 0.05 \pm 0.20 * AOT$.
- Overall, the performance for Aqua is slightly better than Terra. **78.0%** of Aqua and **76.4%** of Terra matchups fall into the expected error range.

Deep Blue Aerosol Data Continuity from MODIS to VIIRS

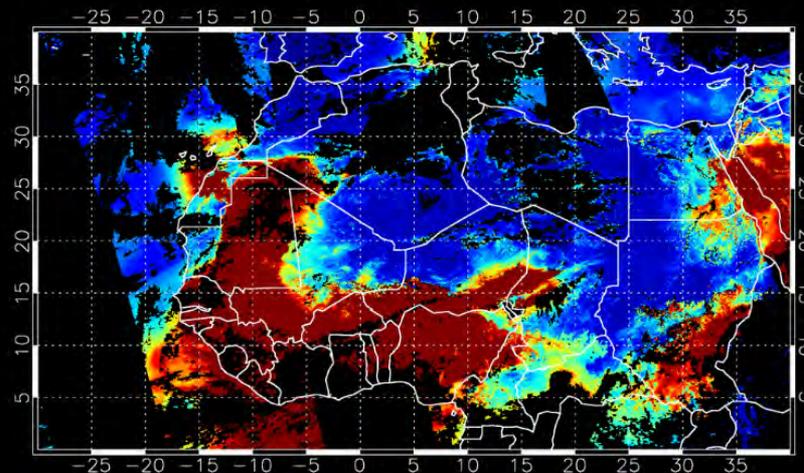
Extending Deep Blue Aerosol Products from MODIS to VIIRS

S-NPP/VIIRS RGB

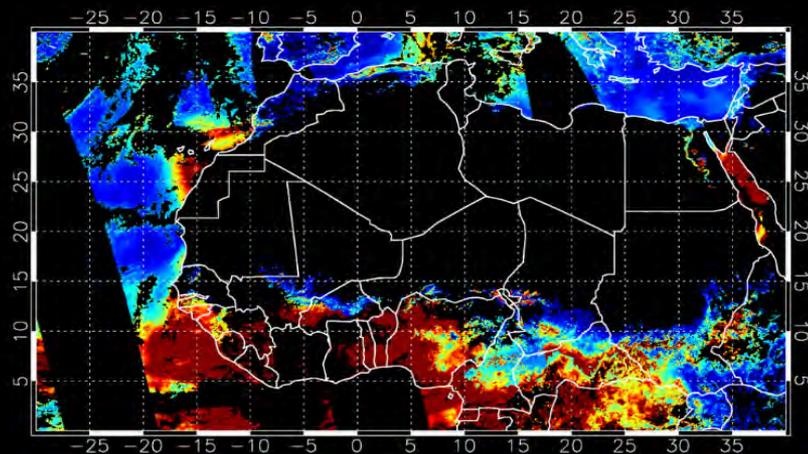
March 22, 2012



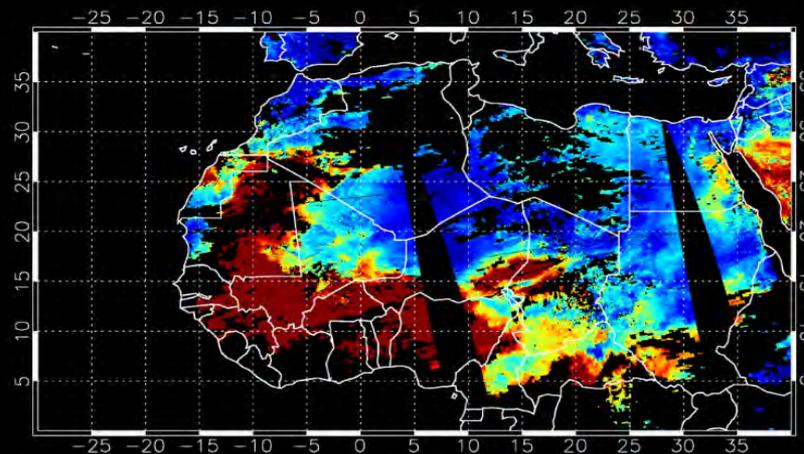
VIIRS Deep Blue AOD



VIIRS Operational IDPS AOD



MODIS C6 Deep Blue AOD



Aerosol Optical Thickness



Aerosol Optical Thickness



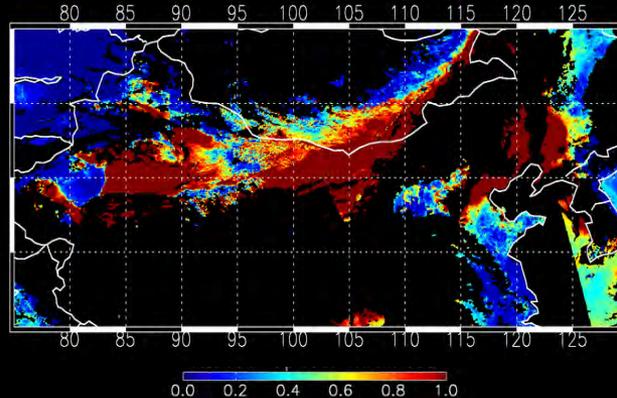
Extending Deep Blue Aerosol Products from MODIS to VIIRS

S-NPP/VIIRS RGB

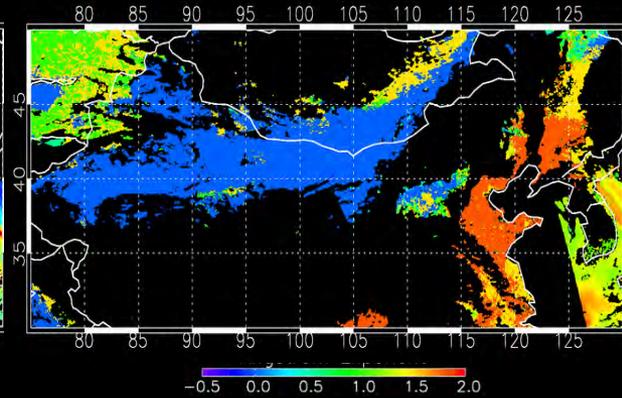
April 23, 2012



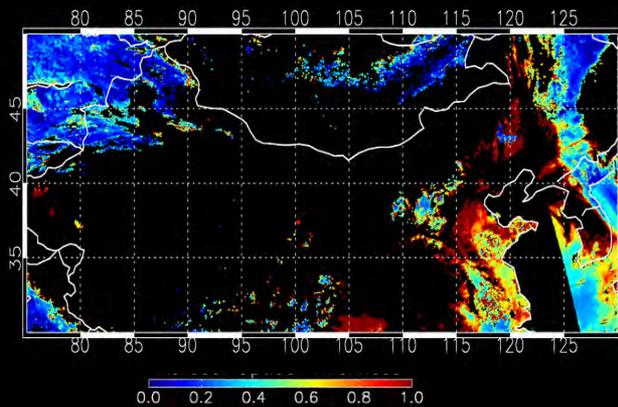
VIIRS Deep Blue AOD



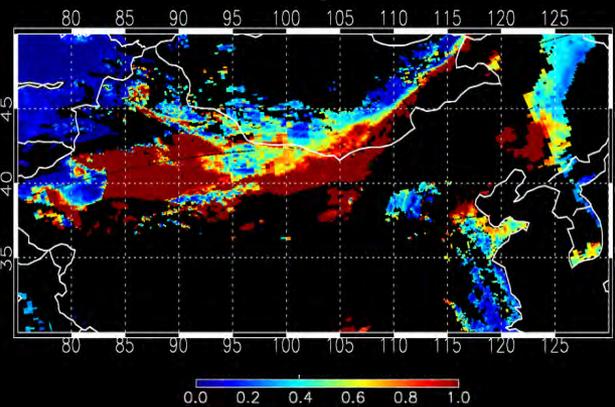
VIIRS Deep Blue AE



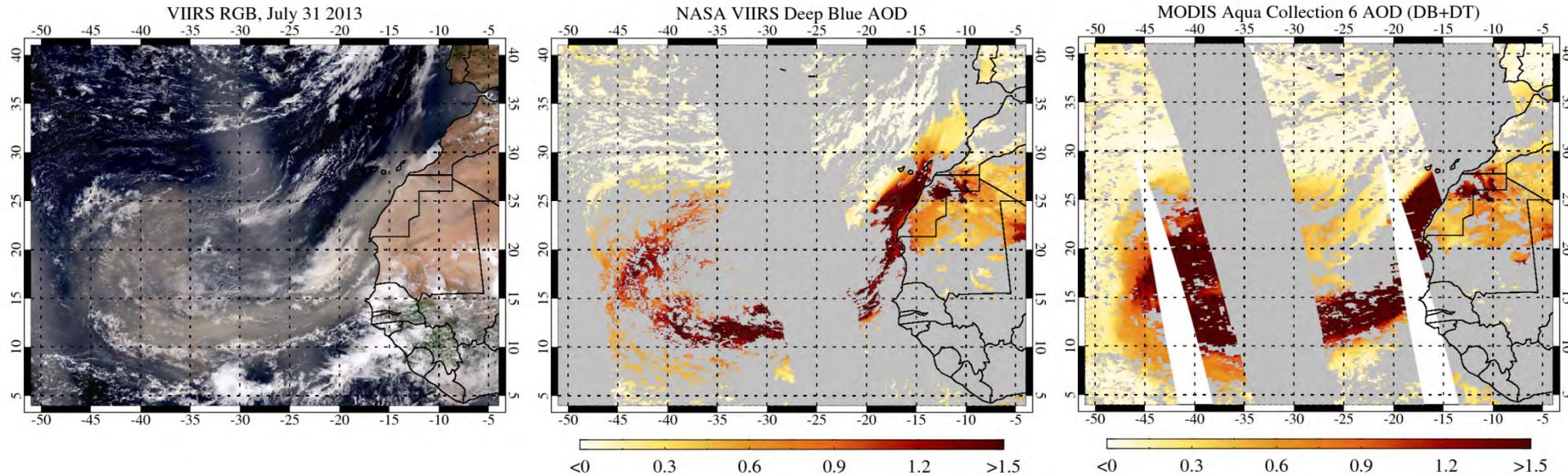
VIIRS IDPS AOD



MODIS Deep Blue AOD

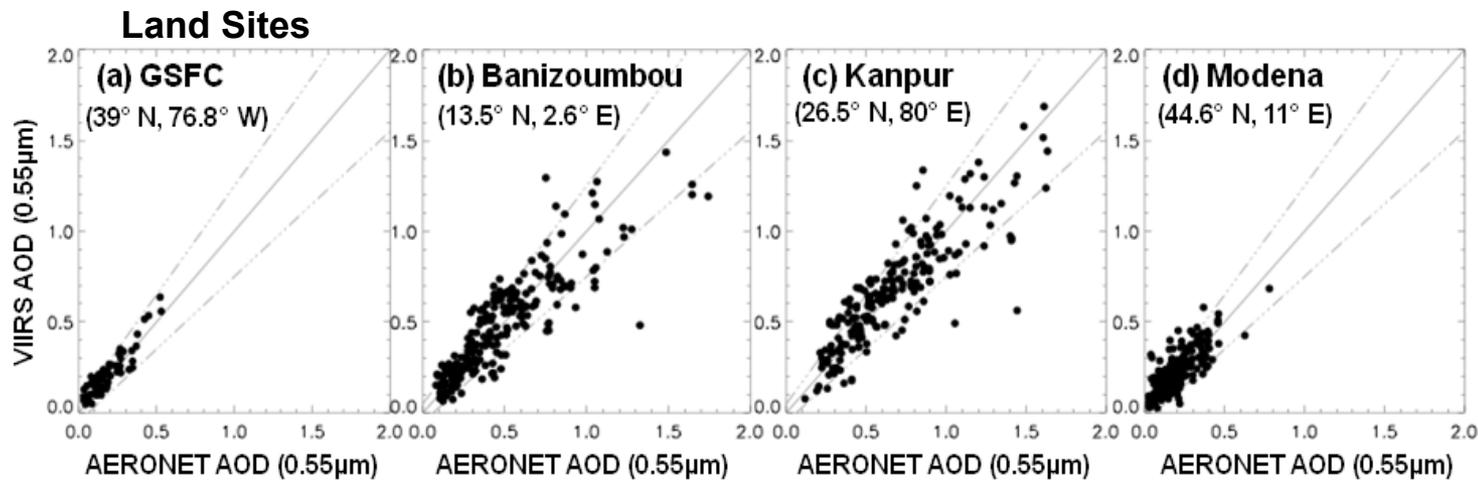
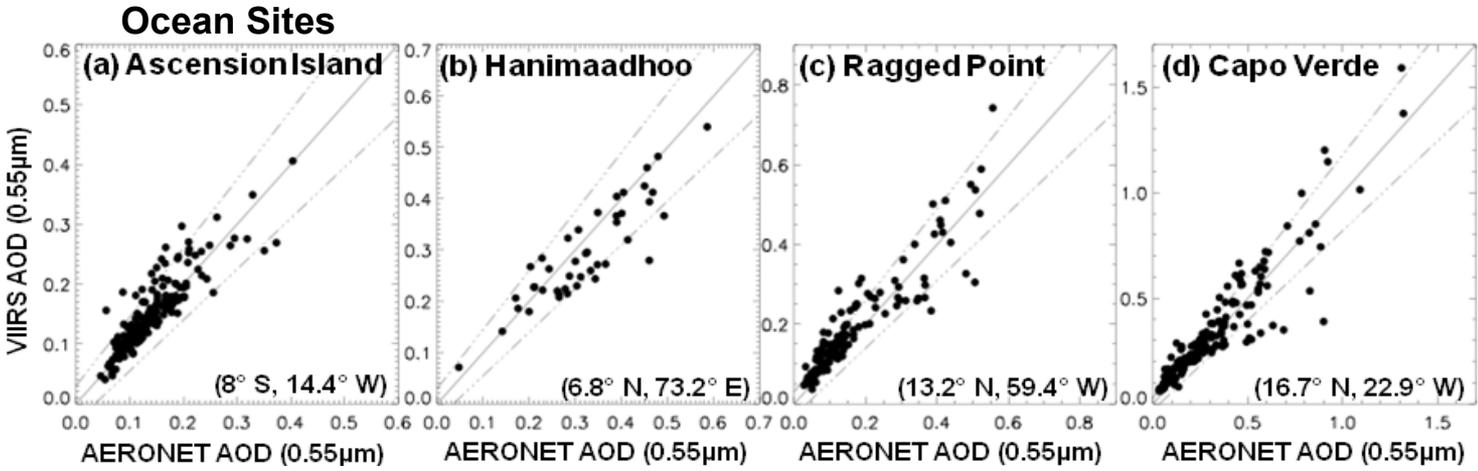


VIIRS ocean retrieval algorithm



- The VIIRS ocean algorithm is an extension and improvement on our SeaWiFS algorithm
 - Similar principles to other common approaches (e.g. MODIS)
- Retrieve AOD, fine mode fraction (Ångström exponent), aerosol type (from a selection of models)
 - Includes nonspherical dust model
- Cloud screening seems effective even in heavy aerosol loading
- Note that MODIS looks more spatially complete because of coarser spatial resolution (nominal 10 km vs. 6 km)

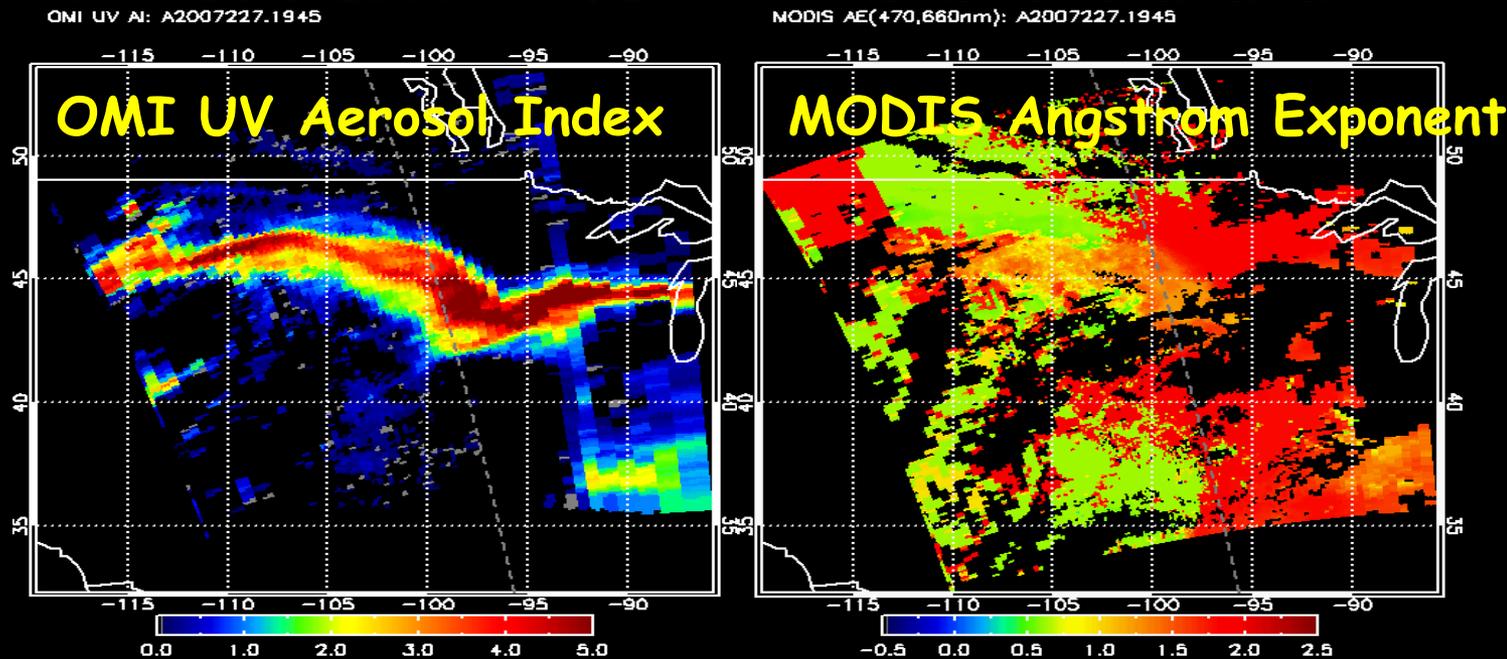
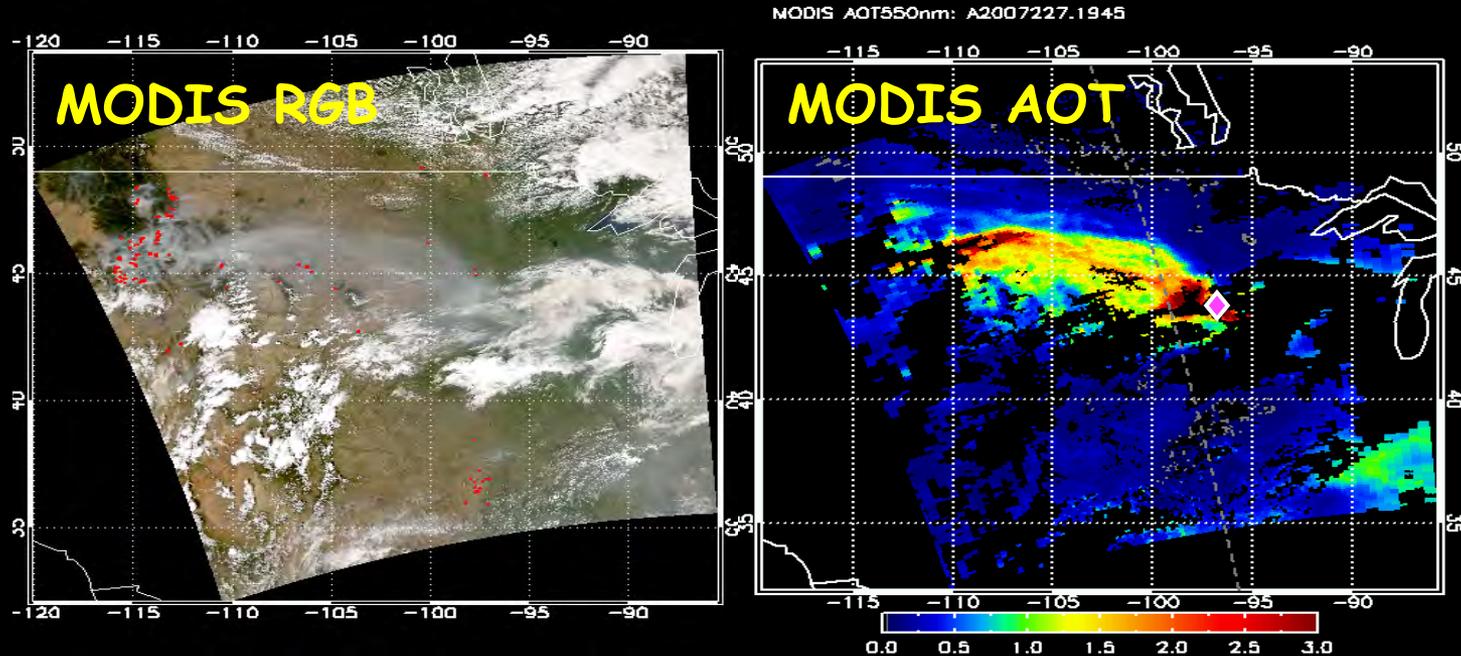
Comparisons of VIIRS Deep Blue AOD with AERONET



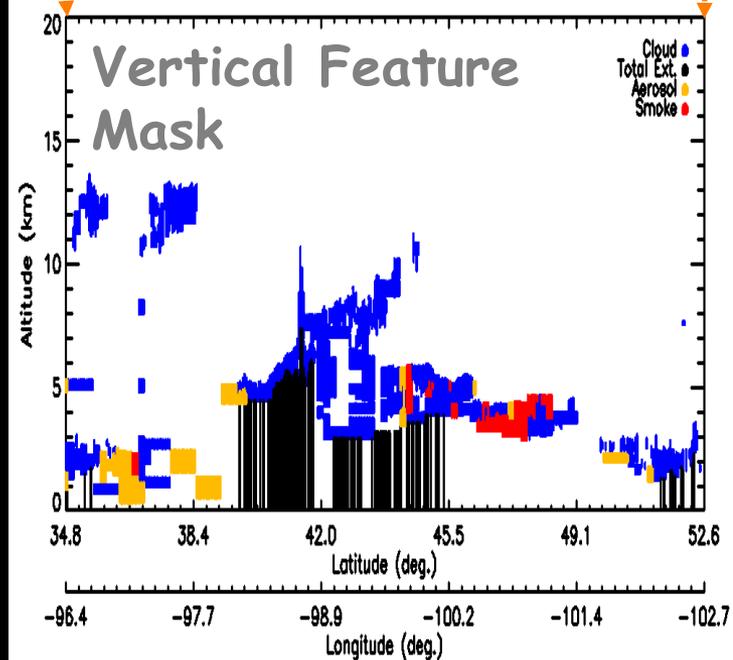
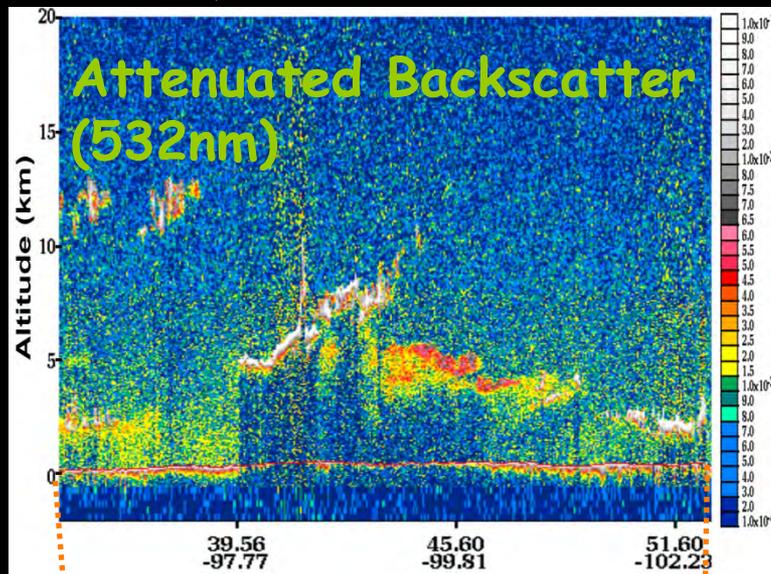
Planning for MODIS Collection 7:

- (1) Provide New Aerosol Plume Height product using combined MODIS and OMI data**

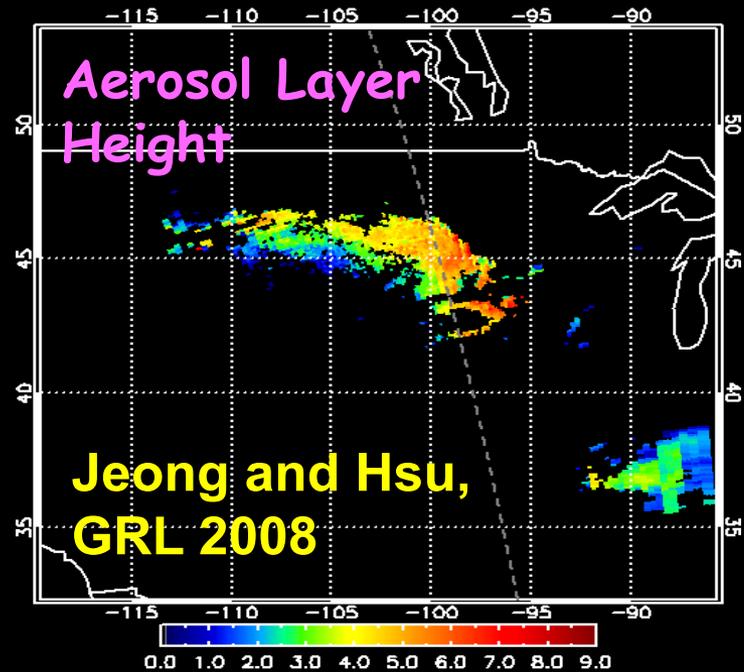
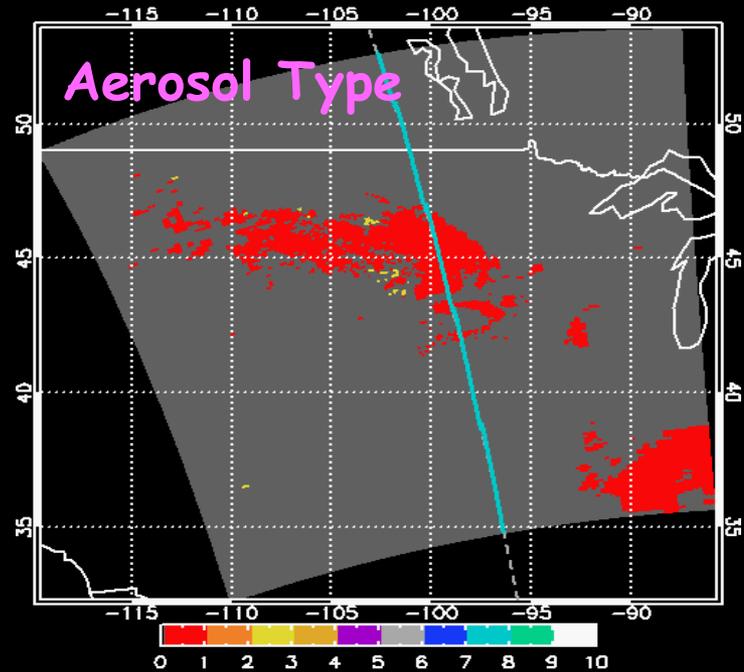
Aerosol Synergy using A-Train Satellite Measurements



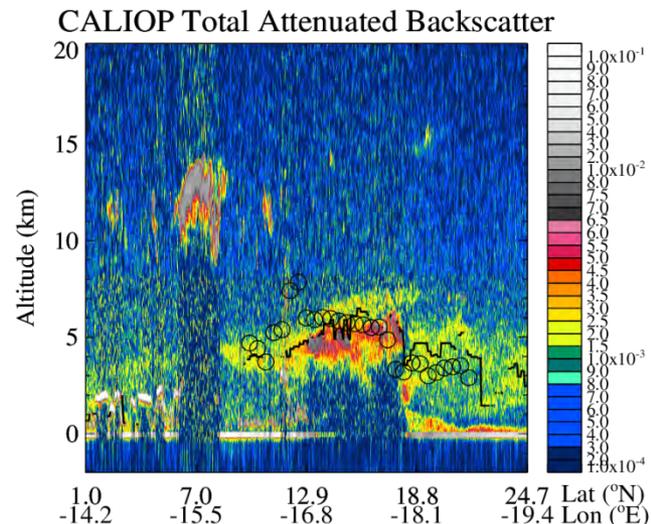
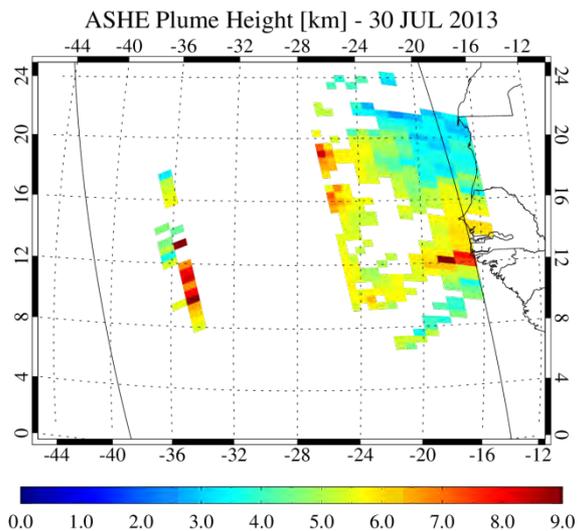
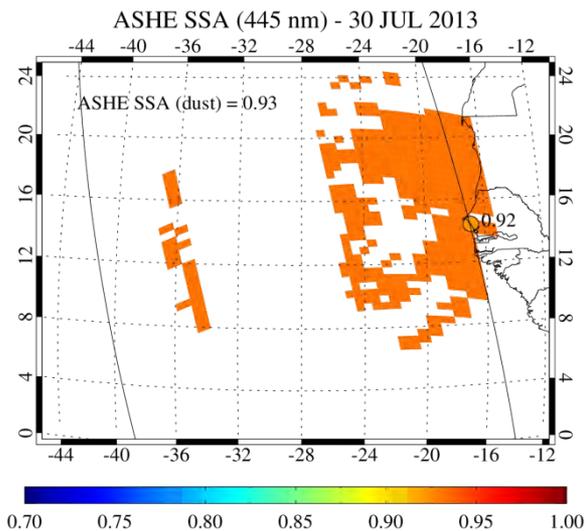
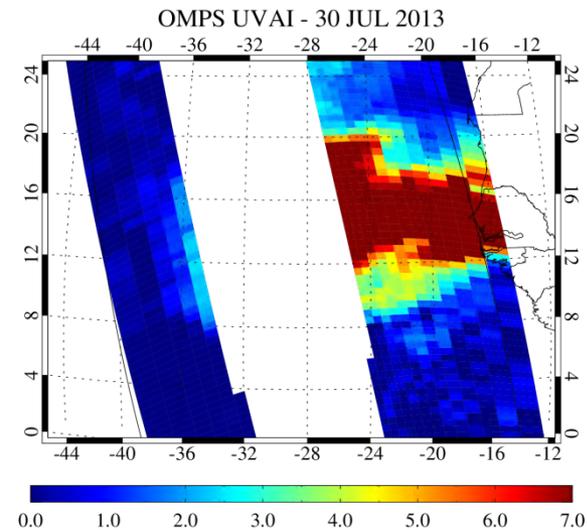
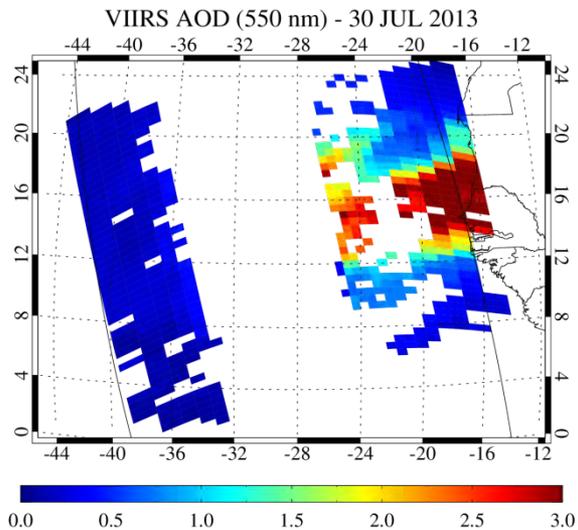
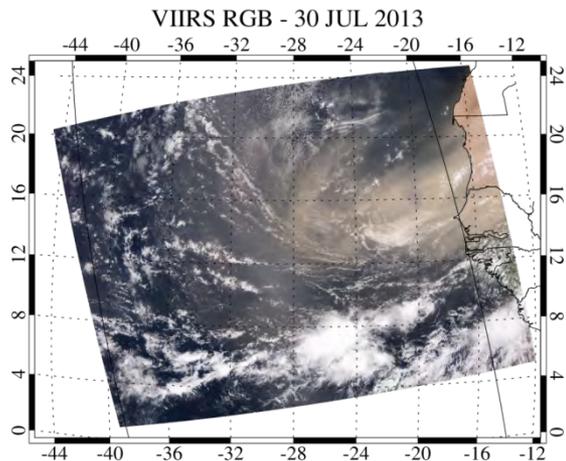
CALIPSO ↓ ASHE →



Aerosol Type V2: A2007227.1945

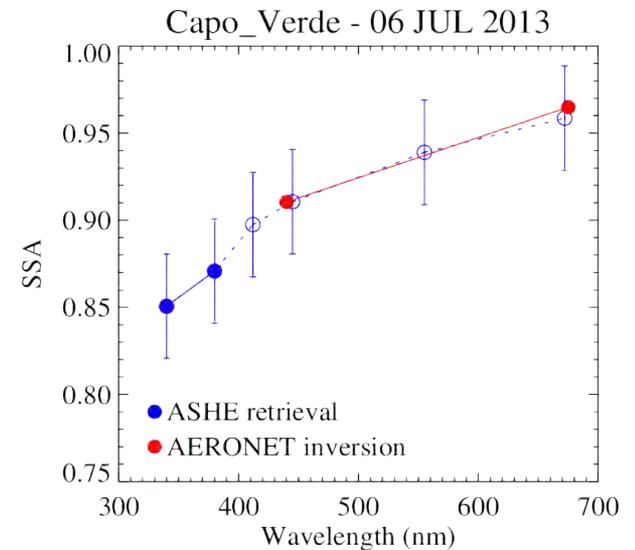
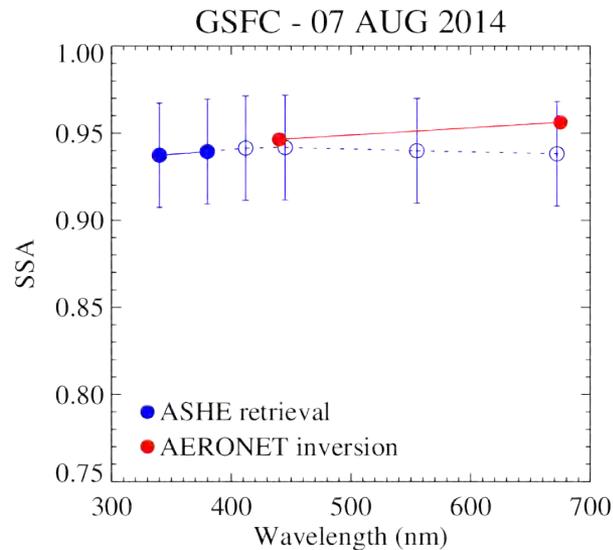
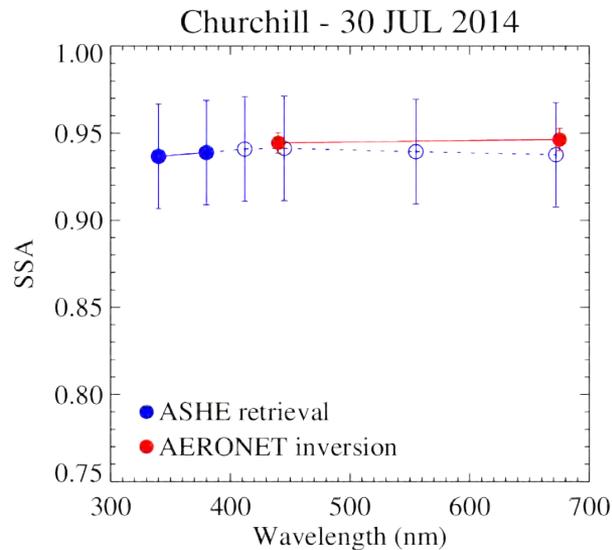
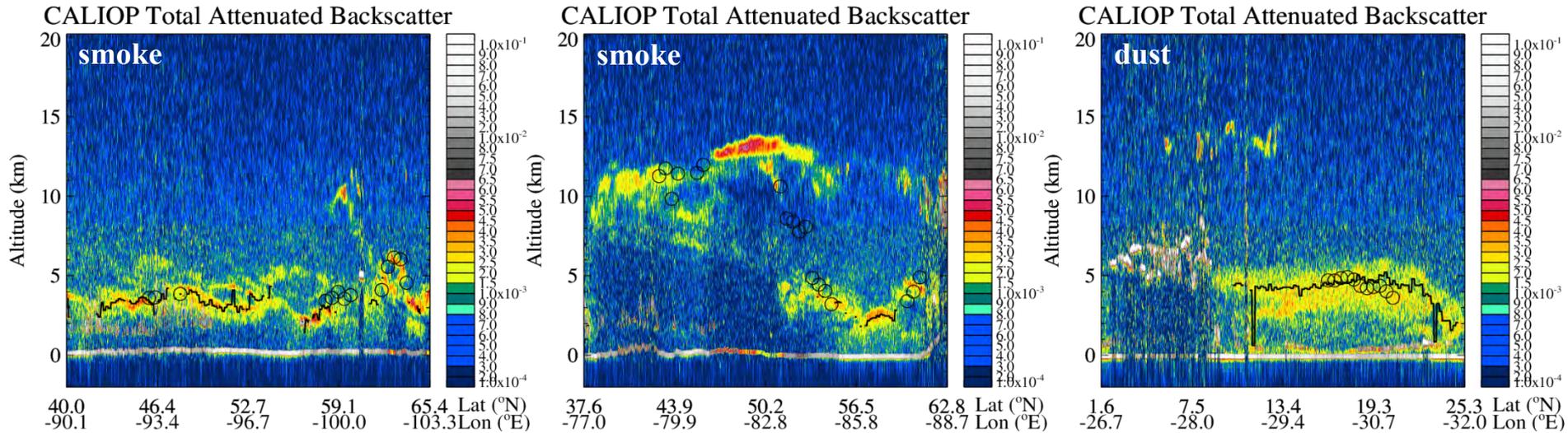


Application to Saharan Dust



Evaluation

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LEE ET AL. POSTER

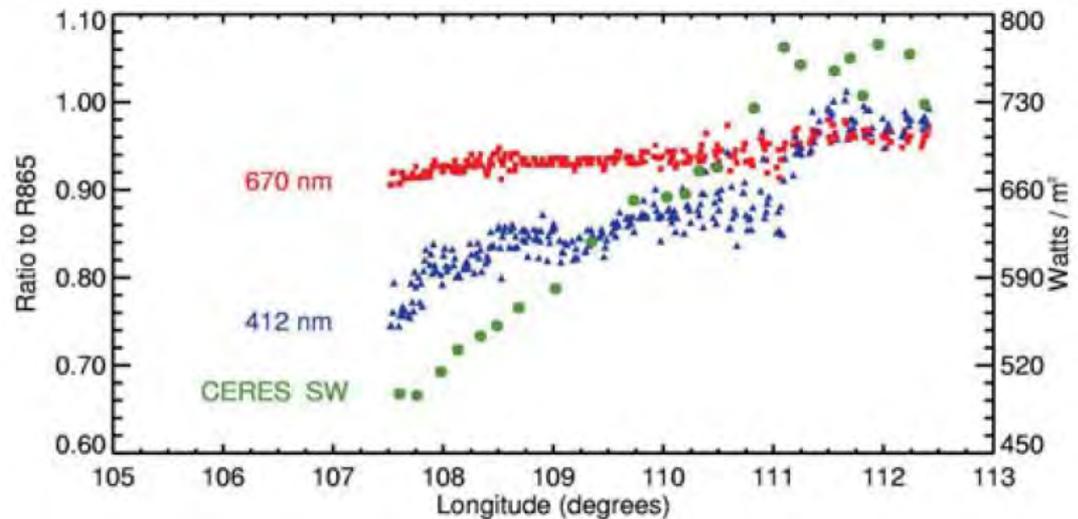
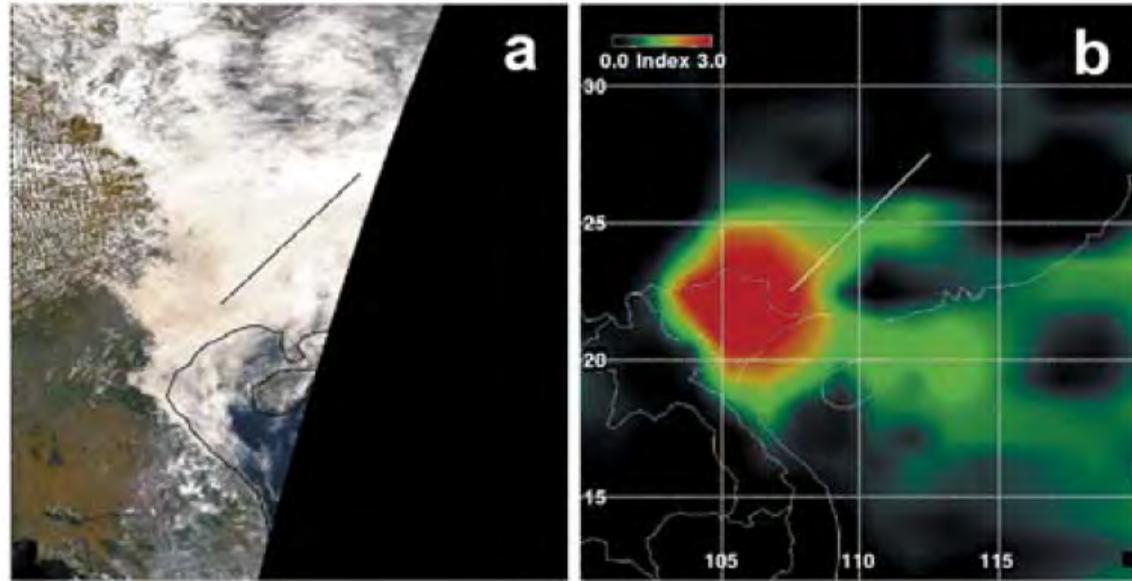


Planning for MODIS Collection 7:

- (2) Extending Deep Blue Aerosol Products from Cloud free to Cloudy regions**

Absorbing aerosols above clouds (AAC)

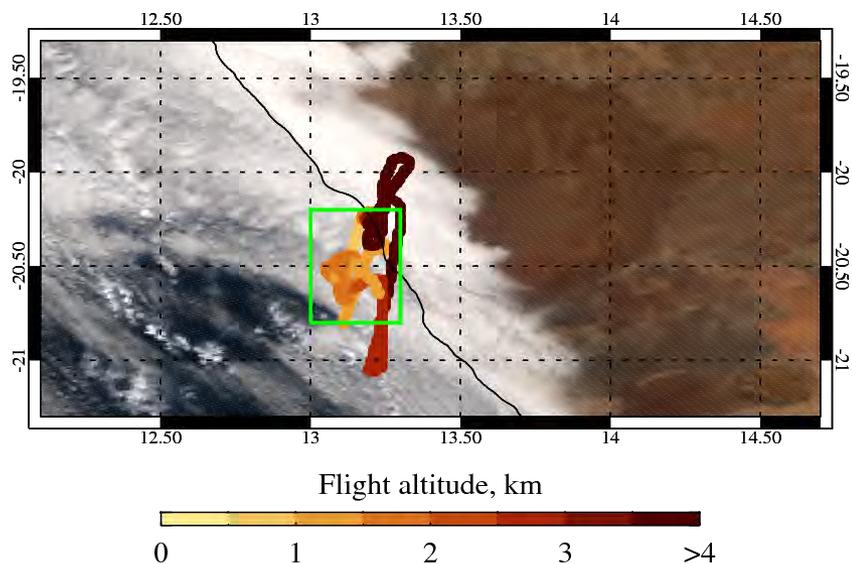
- Absorbing aerosols (smoke, dust) above clouds are a regular feature in many parts of the world
 - Excluded from current operational passive imager-based aerosol data sets
 - Lead to biases in cloud retrievals
 - Radiative effects
- Detectable with MODIS-like sensors by decrease of midvisible or UV reflectance induced by aerosol absorption
- Plan: **retrieve AOD and COD**



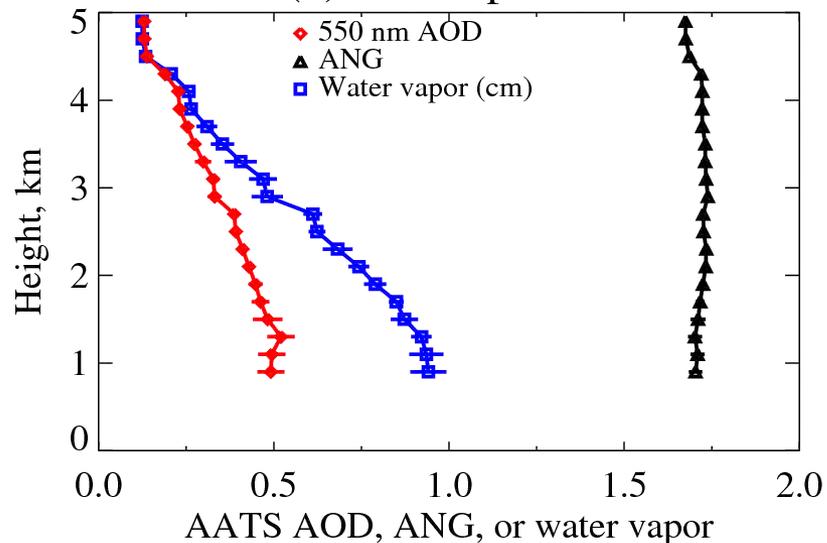
**SEE ALSO
SAYER ET AL. POSTER**

From Hsu *et al.*, JGR (2003)

(a) MODIS Terra 13 Sep 2000 09:25

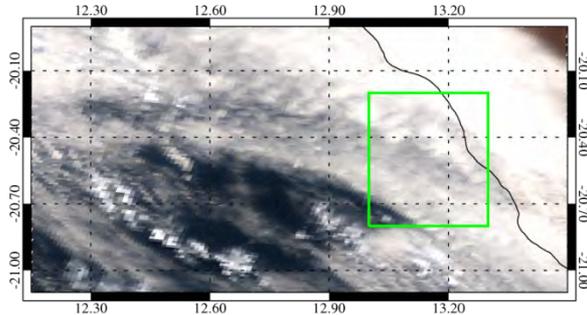


(b) AATS profile

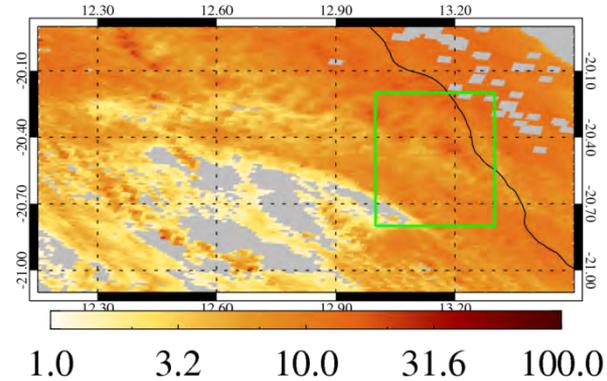


- Validation case studies: take advantage of field campaign observations of aerosols above clouds
 - Observations from the Ames Airborne Tracking Sunphotometer (AATS; <http://geo.arc.nasa.gov/sgg/AATS-website/>)
 - Example from SAFARI-2000: smoke over a flat (~1 km) stratocumulus deck off the coast of Namibia

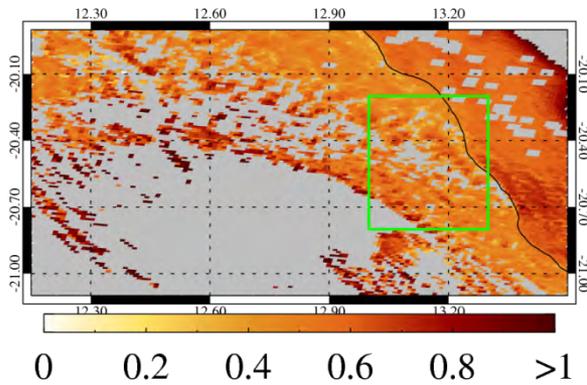
(a) MODIS Terra 13 Sep 2000 09:25



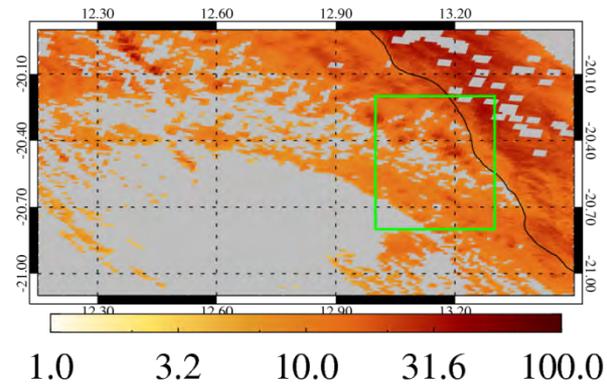
(b) C6 COD (liquid)



(c) AAC AOD



(d) AAC COD



- Preliminary results are encouraging:
 - AATS 550 nm AOD: **0.49+/-0.02**; our MODIS AOD retrieval: **0.51+/-0.09**
 - Our COD is well-correlated with but ~50% higher than operational C6 product, consistent with strong absorption by the smoke
 - Note low-COD pixels are removed by our algorithm, as it requires opaque clouds

Summary

- **Spatial coverage and retrieval accuracy are substantially improved in the MODIS C6 Deep Blue aerosol products compared to C5**
 - **Enhancements in surface reflectance determination, cloud screening, utilization of thermal IR bands**
 - **Based upon comparisons with global AERONET AOD observations, the expected error for MODIS C6 DB is about $\pm(0.05+20\%)$**
 - **Terra performance is a little poorer than Aqua due to sensor degradation**
- **VIIRS Deep Blue has similar quality to MODIS; beta release later this year, including over-ocean retrievals**
- **Started planning for the MODIS C7 reprocessing to implement aerosol plume height and aerosol above cloud retrievals**

For more details, see our posters:

- 1. Sayer *et al.*, “*First results extending MODIS Deep Blue aerosol retrieval coverage to cases of absorbing aerosols above clouds*”**
- 2. Lee *et al.*, “*Retrieving plume height of smoke and dust by synergistic use of VIIRS, OMPS, and CALIOP observations*”**
- 3. Bettenhausen *et al.*, “*Effects of Terra calibration on long-term aerosol optical thickness products*”**
- 4. Bettenhausen *et al.*, “*Introducing the VIIRS Deep Blue aerosol products: towards a long-term multi-sensor record*”**